

**CLAIMS**

1. Method for estimating a propagation channel in the presence of transmit beamforming, accounting for the structure of two logical channels (CPICH, DPCH) and based on a common structure of corresponding propagation channels, said second logical channel (DPCH) comprising two sub-channels (DPDCH, DPCCH), said propagation channels  
5 being modeled as a linear superposition of a finite number of discrete multipath components ( $p=1, \dots, P$ ) following an uncorrelated-scattering wide-sense stationary model, a multipath component being characterized by a time-varying multipath complex coefficient ( $c_p(t)$  and  $\beta_p c_p(t)$ ) and a delay ( $\tau_p$ ).
  
2. A method for estimating a propagation channel in the presence of transmit beamforming  
10 as claimed in claim 1, characterized in that said propagation channel correspond to the first sub-channel (DPDCH) and that said method provides estimates of each multipath component ( $p=1, \dots, P$ ) complex coefficient ( $\beta_p c_p(t)$ ) according to a maximum-a-posteriori MAP optimization criterion accounting for the whole available information associated with said logical (CPICH, DPCH) and corresponding propagation channels,  
15 through the following processing steps of:
  1. building a second channel (DPCH) and a first channel (CPICH) instantaneous maximum likelihood ML channel multipath complex coefficients estimates ( $\hat{c}_{dpch}(n)$  and  $\hat{c}_{cpich}(n)$ ),
  2. performing interpolation of the above obtained ML instantaneous second  
20 (DPCH) and first (CPICH) channel multipath complex coefficient estimates ( $\hat{c}_{dpch}(n)$  and  $\hat{c}_{cpich}(n)$ ) to the lowest symbol rate of said second (DPCH) and first (CPICH) logical channels,
  3. computing an optimal linear prediction filter ( $f$ ) according to a joint second and first channels (DPCH-CPICH) maximum-a-posteriori (MAP) criterion,
  - 25 4. filtering the interpolated ML instantaneous second (DPCH) and first (CPICH) channel multipath complex coefficient estimates obtained at step 2 with said

optimal linear prediction filter in order to obtain a MAP first sub-channel (DPDCH) multipath coefficient estimate ( $\tilde{c}_{dpdch-MAP}(k)$ ), and

5. interpolating said MAP first sub-channel (DPDCH) multipath coefficient estimate ( $\tilde{c}_{dpdch-MAP}(k)$ ) to the second logical channel (DPCH) symbol rate when said symbol rate is lower than the first logical channel (CPICH) symbol rate,

where steps 1 to 5 are repeated for all multipath component ( $p=1, \dots, P$ ) complex coefficients ( $\beta_p c_p(t)$ ).

3. A second method for estimating a propagation channel in the presence of transmit beamforming characterized in that said propagation channel corresponds to the first sub-channel (DPDCH) and that said method provides estimates of each multipath component ( $p=1, \dots, P$ ) complex coefficient, accounting for the whole available information associated with said logical (CPICH, DPCH) and corresponding propagation channels, through the following processing steps of:

1. building a second channel (DPCH) and a first channel (CPICH) instantaneous maximum likelihood ML channel multipath coefficients estimates ( $\hat{c}_{dpch}(n)$  and  $\hat{c}_{cpich}(n)$ ),
2. performing interpolation of said ML instantaneous first (DPCH) and second (CPICH) channel multipath coefficient estimates ( $\hat{c}_{dpch}(n)$  and  $\hat{c}_{cpich}(n)$ ) to the lowest symbol rate of said second (DPCH) and first (CPICH) logical channels,
3. building an optimal maximum a posteriori estimate ( $\tilde{c}_{cpich-MAP}(k)$ ) of the first (CPICH) channel multipath coefficient ( $c_{cpich}(k)$ ),
4. building an estimate of the cross-correlation ( $\hat{\phi}_{dc}(l)$ ) between the first (CPICH) and second (DPCH) channel multipath coefficient instantaneous maximum likelihood estimates obtained at step 2 ( $\hat{c}_{dpch}$  and  $\hat{c}_{cpich}$ ) and an estimate of the autocorrelation ( $\hat{\phi}_{cc}(l)$ ) between the (CPICH) channel multipath coefficient instantaneous maximum likelihood estimates ( $\hat{c}_{cpich}$ ) of step 1 and 2 at non-zero correlation lag ( $l \neq 0$ ) for noise suppression,
5. building an estimate ( $\hat{\beta}$ ) of a beamforming complex factor ( $\beta$ ) from said cross-correlation and autocorrelation estimates,

6. building a first sub-channel (DPDCH) multipath coefficient estimate ( $\tilde{c}_{dpdch}(k)$ )  
as the product of the estimates obtained at steps 3 ( $\tilde{c}_{cpich-MAP}(k)$ ) and 5 ( $\hat{\beta}$ ), and
7. interpolating said first sub-channel (DPDCH) multipath coefficient estimate  
( $\tilde{c}_{dpdch}(k)$ ) to the second logical channel (DPCH) symbol rate when said symbol  
5 rate is lower than the first logical channel (CPICH) symbol rate,  
where steps 1 to 7 are repeated for all multipath component ( $p=1, \dots, P$ ) complex  
coefficients ( $\beta_p c_p(t)$ ).
4. A method as claimed in claims 2 and 3, characterized in that the first logical channel  
(CPICH) maximum likelihood channel multipath coefficient estimates ( $\hat{c}_{cpich}(n)$ ), are  
10 computed based on the a-priori knowledge of some pilot symbols forming said first  
logical channel (CPICH).
5. A method as claimed in claims 2 and 3, characterized in that the second logical channel  
(DPCH) maximum likelihood channel multipath coefficient estimates ( $\hat{c}_{dpch}(n)$ ), related  
to the second sub-channel (DPCCH) are computed based on the a-priori knowledge of  
15 the pilot symbols forming said second sub-channel (DPCCH).
6. A method as claimed in claims 2 and 3, characterized in that the second logical channel  
(DPCH) maximum likelihood channel multipath coefficient estimates ( $\hat{c}_{dpch}(n)$ ) related  
to the first sub-channel (DPDCH) are computed by a decision-direct mechanism.
7. A method as claimed in claims 2 and 3, characterized in that the interpolation of step 2  
20 is performed by nearest neighbor interpolation.
8. A method as claimed in claim 2, characterized in that the optimal linear prediction filter  
is built according to the maximum-a-posteriori optimization criterion, based on the  
interpolated maximum likelihood channel multipath coefficients estimates ( $\hat{c}_{cpich}(n)$  and  
 $\hat{c}_{dpch}(n)$ ) related to said first (CPICH) and second (DPCH) logical channels in order to  
25 provide an optimal by joint second and first channel (DPCH-CPICH) maximum-a-  
posteriori first sub-channel (DPDCH) multipath coefficient estimate ( $\tilde{c}_{dpdch-MAP}(k)$ ).

9. A method as claimed in claim 3, characterized in that a maximum likelihood estimate of the second (DPCH) corresponding propagation channel and first (CPICH) corresponding propagation channel cross-correlation ( $E\{\hat{c}_{dpch}(n)\hat{c}_{cpich}^*(n-l)\}$ ) and a maximum likelihood estimate of the first (CPICH) corresponding propagation channel autocorrelation ( $E\{\hat{c}_{cpich}(n)\hat{c}_{cpich}^*(n-l)\}$ ) are computed based on the sample moments ( $\hat{\phi}_{dc}(l)$  and  $\hat{\phi}_{cc}(l)$ ) of the first (CPICH) and second (DPCH) channel maximum likelihood estimates ( $\hat{c}_{cpich}(n)$  and  $\hat{c}_{dpch}(n)$ ) of step 1 and 2.
10. A method as claimed in claim 3, for the computation of the estimate of said complex beamforming factor ( $\beta$ ) characterized in that the second logical channel (DPCH) and the first logical channel (CPICH) corresponding propagation channel cross-correlation and the first logical channel (CPICH) corresponding propagation channel autocorrelation maximum likelihood estimates ( $\hat{\phi}_{dc}(l)$  and  $\hat{\phi}_{cc}(l)$ ) at different correlation lags ( $l=1, 2, \dots, L$ ) are linearly combined ( $\sum_{l=1}^L a_l \hat{\phi}_{dc}(l)$  and  $\sum_{l=1}^L b_l \hat{\phi}_{cc}(l)$ ).
11. A method as claimed in claim 3, characterized in that the second logical channel (DPCH) and first logical channel (CPICH) cross-correlation and the first logical channel (CPICH) autocorrelation successive estimates ( $\hat{\phi}_{dc}(l)$  and  $\hat{\phi}_{cc}(l)$ ) are taken at a fixed lag ( $l$ ) and are low-pass filtered for the computation of the estimate of said complex factor ( $\beta$ ).
12. A method as claimed in claim 3, characterized in that the estimate of said complex factor ( $\beta$ ) is built as a linear combination of the beamforming complex factor estimates computed as the ratio of the second logical channel (DPCH) and the first logical channel (CPICH) corresponding propagation channels cross-correlation and the first logical channel (CPICH) corresponding propagation channel autocorrelation estimates at a certain lag ( $l$ ) ( $\hat{\beta}_{ML}(l) = \hat{\phi}_{dc}(l) / \hat{\phi}_{cc}(l)$ ), ( $\hat{\beta} = \sum_{l=1}^K \gamma_l \hat{\beta}_{ML}(l)$ ) at lag  $l=1, 2, \dots, K$ .
13. A method as claimed in any one of claims 10, 11 or 12, characterized in that the estimate of said complex factor ( $\beta$ ) is limited to the lag equal to 1.
14. A receiver utilizing said methods as claimed in any one of claims 1, 2 or 3.

15. An Estimator for estimating a propagation channel in the presence of transmit beamforming, accounting for the structure of two logical channels referred as to a common channel and a dedicated physical channel (CPICH, DPCH) and based on a common structure of corresponding propagation channels, said dedicated physical channel (DPCH) comprising two sub-channels (DPDCH, DPCCH), said propagation channels being modeled as a linear superposition of a finite number ( $p=1, \dots, P$ ) of discrete multipath components following an uncorrelated-scattering wide-sense stationary model, a multipath component being characterized by a time-varying multipath complex coefficient ( $c_p(t)$  and  $\beta_p c_p(t)$ ) and a delay ( $\tau_p$ ).

16. An estimator as claimed in claim 15 for estimating a propagation channel in the presence of transmit beamforming, characterized in that said propagation channel corresponds to the first sub-channel (DPDCH) estimation and that said estimator comprises:

- Means to build a second (DPCH) and a first (CPICH) logical channel corresponding propagation channel instantaneous maximum likelihood ML channel multipath coefficient estimates ( $\hat{c}_{cpich}(n)$  and  $\hat{c}_{dpch}(n)$ ),
- Means to perform interpolation of the above obtained ML instantaneous second (DPCH) and first (CPICH) logical channel corresponding propagation channel multipath coefficient estimates ( $\hat{c}_{cpich}(n)$  and  $\hat{c}_{dpch}(n)$ ) to the lowest symbol rate of said second (DPCH) and first (CPICH) logical channels,
- Means to build an optimal linear prediction filter according to a joint second and first (DPCH-CPICH) channel maximum-a-posteriori criterion,
- Means to build a first sub-channel (DPDCH) multipath coefficient estimate ( $\tilde{c}_{dpdch-MAP}(k)$ ) by filtering with said optimal linear prediction filter with said interpolated ML instantaneous second (DPCH) and first (CPICH) logical channel corresponding propagation channel multipath coefficient estimates ( $\hat{c}_{cpich}$  and  $\hat{c}_{dpch}$ ), obtained at step 2, and
- Means to interpolate said first sub-channel (DPDCH) multipath coefficient estimate ( $\tilde{c}_{dpdch-MAP}(k)$ ) to the second logical channel (DPCH) symbol rate when said symbol rate is lower than the first logical channel (CPICH) symbol rate.

17. An estimator as claimed in claim 15 for estimating a propagation channel in the presence of transmit beamforming, characterized in that said propagation channel corresponds to the first-sub-channel (DPDCH) and that said estimator comprises:

- 5      • Means to build a second (DPCH) and a first (CPICH) logical channel corresponding propagation channel instantaneous maximum likelihood ML channel multipath coefficient estimates ( $\hat{c}_{cpich}(n)$  and  $\hat{c}_{dpch}(n)$ ),
- Means to perform interpolation of the above obtained ML instantaneous second (DPCH) and first (CPICH) logical channel corresponding propagation channel multipath coefficient estimates ( $\hat{c}_{cpich}(n)$  and  $\hat{c}_{dpch}(n)$ ) to the lowest symbol rate of said
- 10      second (DPCH) and first (CPICH) logical channels,
- Means to build an optimal maximum a posteriori estimate ( $\tilde{c}_{cpich-MAP}(k)$ ) of the first logical channel (CPICH) multipath coefficient ( $c_{cpich}(k)$ ),
- Means to build an estimate ( $\hat{\phi}_{dc}(l)$ ) of the cross-correlation ( $E\{\hat{c}_{dpch}(n)\hat{c}_{cpich}^*(n-l)\}$ ) between the first (CPICH) and second (DPCH) logical channel corresponding
- 15      propagation channel multipath coefficient instantaneous maximum likelihood estimates ( $\hat{c}_{cpich}(n)$  and  $\hat{c}_{dpch}(n)$ ), and an estimate ( $\hat{\phi}_{cc}(l)$ ) of the autocorrelation ( $E\{\hat{c}_{cpich}(n)\hat{c}_{cpich}^*(n-l)\}$ ) between the first logical channel (CPICH) corresponding propagation channel multipath coefficient instantaneous maximum likelihood estimates ( $\hat{c}_{cpich}(n)$ ), of step 1 and 2 of claim 3, at non-zero correlation lag ( $l \neq 0$ ) for
- 20      noise suppression,
- Means to estimate a beamforming complex factor ( $\beta$ ) from said cross-correlation and the auto correlation estimates ( $\hat{\phi}_{dc}(l)$  and  $\hat{\phi}_{cc}(l)$ ),
- Means to build a first sub-channel (DPDCH) multipath coefficient estimate ( $\tilde{c}_{dpdch}(k)$ ) as the product of the optimal maximum a posteriori estimate ( $\tilde{c}_{cpich-MAP}(k)$ )
- 25      of the first channel (CPICH) multipath coefficient and the cross-correlation and the auto correlation estimates ( $\hat{\phi}_{dc}(l)$  and  $\hat{\phi}_{cc}(l)$ ),
- Means to interpolate said first sub-channel (DPDCH) multipath coefficient estimate ( $\tilde{c}_{dpdch}(k)$ ) to the second logical channel (DPCH) symbol rate when said symbol rate is lower than the first logical channel (CPICH) symbol rate.

30      18. A receiver comprising an estimator as claimed in claim 15.

19. A communication system using a method for estimating a propagation channel in the presence of transmit beamforming as claimed in claim 1, when information data are transmitted through a beamforming system.